Tool 11
Urban Forestry Planning and the Leaf Out Analysis

This tool provides a chapter from the Center for Watershed Protection's Urban Watershed Forestry Manual, Part 1, which guides the watershed planner or forester through a six-step method for increasing forest cover in a watershed, defining watershed-based forest covers goals, and identifying priority sites for protection, restoration and reforestation

CHAPTER 2: PLANNING METHOD FOR INCREASING FOREST COVER IN THE WATERSHED

This chapter guides the watershed planner or forester through a six-step method for increasing forest cover in the watershed that includes defining watershed-based forest cover goals and identifying priority sites for protection, restoration and reforestation (Figure 8). These methods are only one component of the larger urban watershed restoration process, and should be coordinated with other restoration practices outlined in Schueler (2004). For example, the baseline and sentinel monitoring of watershed conditions recommended in Schueler (2004) are essential to evaluate the effect of increasing forest cover through urban watershed forestry techniques.

Figure 8 presents the six-step method for increasing watershed forest cover, which is explained in detail in this chapter.

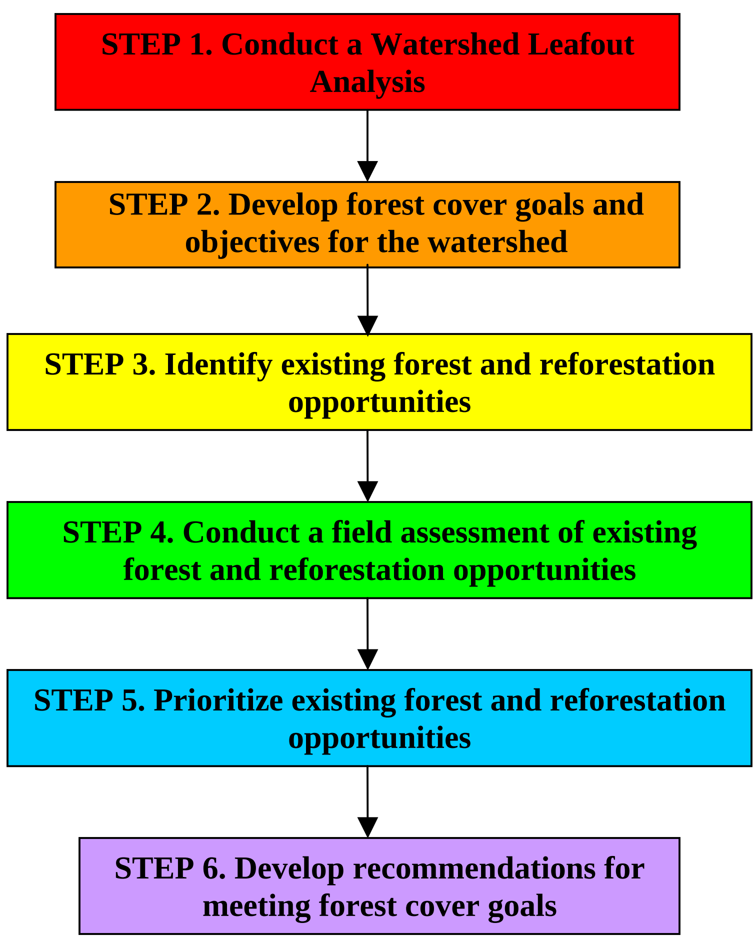


Figure 8. Six-step process for increasing forest cover in the watershed

The six-step method described here focuses on *planning* to increase forest cover in the watershed. Detailed guidance on *implementation* of techniques to increase forest cover is outside the scope of this manual; however, specific references are made throughout to direct the reader to the best implementation resources. This method is based on the assumption that a municipal or community program has mapping and other resources and the ability to conduct the method.

The method is typically conducted across an entire watershed or subwatershed, but could easily be applied to a different scale, such as a small urban catchment or an entire metropolitan area. In addition, the actual implementation of several of the steps occurs at the individual parcel scale (e.g., evaluating reforestation sites, implementing reforestation projects). The use of Geographic Information Systems (GIS) is required for the method and the resolution of data should be appropriate for the scale of analysis (see text box on following page).

Step 1: Conduct a Watershed "Leafout Analysis"

Watersheds are constantly gaining and losing forest cover at the same time due to the clearing of forests for land development, homeowner landscaping, abandonment of farm land or open space, reforestation or other activities. The first step entails an inventory of existing and future watershed land cover to systematically account for forest losses and gains. The method described here is referred to as the "Leafout Analysis" because it is similar to a buildout analysis, which predicts future impervious cover with development based on zoning categories. The Leafout Analysis focuses on future forest cover rather than impervious cover. This analysis can be used to identify and evaluate the location, distribution, average size, future use and ownership of forest fragments and reforestation sites. This information can then be used to determine which types of projects (protection, restoration or reforestation) and what types of lands (public, private, residential turf, parks) will yield the greatest return in terms of increasing forest cover in the watershed. This step requires the use of GIS (see text box on following page).

The substeps of the Leafout Analysis include the following and are described in detail below:

Step 1.1 Estimate the Distribution of Current Land Cover in the Watershed
Step 1.2 Identify Protected and Unprotected Lands in the Watershed
Step 1.3 Determine Whether Parcels are Developed or Undeveloped
Step 1.4 Determine Allowable Zoning on Undeveloped Land
Step 1.5 Summarize Watershed Data
Step 1.6 Acquire Forest Cover Coefficients
Step 1.7 Estimate Future Forest Cover in the Watershed

USING GEOGRAPHIC INFORMATION SYSTEMS FOR THE LEAFOUT ANALYSIS

A Geographic Information System (GIS) is a computer-based tool for mapping and analyzing all sorts of geographically referenced (spatial) data. GIS is a common tool for local governments to manage property data, map natural resources, plan future transportation corridors and provide efficient emergency response. Maintaining a GIS can require extensive resources for data collection, staff training, hardware and software acquisition and more.

The inventory of current and future land cover described in this section requires the use of GIS; therefore, some basic understanding of GIS is helpful to navigate this section. Since a wide variety of GIS software is available, the steps described in this section refer only to general procedures rather than software-specific manipulations. The data layers created in this analysis have applicability and utility across a wide variety of local departments and analyses. The minimum GIS layers required for the inventory of land cover in the watershed are listed below. Many of these layers are available for free download from websites such as the Maryland State Geographic Committee's Technology Toolbox: www.msgic.state.md.us. De la Cretaz (2003) provides some guidance on compiling and analyzing watershed GIS data and Appendix B provides a list of additional data resources.

- Watershed and subwatershed boundaries (delineation methods available at the Storm water Manager's Resource Center: www.stormwatercenter.net)
- Open water and wetlands
- Topography
- Land cover (e.g, impervious, forest, turf)
- Protected lands (e.g., conservation easements)
- Parcel boundaries
- Land use (e.g., schools, parks)
- Zoning
- Natural resources (e.g., stream buffers, steep slopes, floodplains)
- Monitoring data (e.g., water quality, habitat, biological)
- Cultural, recreational or historical sites
- Storm water treatment practices and other drainage features

Step 1.1 Estimate the Distribution of Current Land Cover in the Watershed

The first step is to create or acquire a GIS layer of current land cover in the watershed that distinguishes between three cover types: impervious cover, forest cover and non-forest vegetative cover. Open water and non-forested wetlands are not included in the land cover analysis.

- *Impervious cover* is defined as any surface that does not allow water to infiltrate and typically includes roads, buildings, parking lots, driveways, sidewalks and decks.

- *Forest cover* includes all land that is primarily covered by trees and shrubs, although the actual classification of forest cover can vary greatly with the data source (see text box on page 2). The ideal forest cover layer in this scenario is actually urban tree canopy, which includes the canopy of individual trees, groups of trees and forests.

- *Non-forest vegetative cover* can include turf, bare ground, landscaping, meadow and crops. In urban watersheds, the majority of non-forest vegetation is usually turf. Since it is difficult to distinguish between these cover types from aerial photos, and because all of these cover types are potential reforestation candidates, any land cover that is not forest or impervious is considered turf for the purposes of this analysis.

Depending on current GIS data, staff expertise and resources available, there are three options for obtaining a current land cover layer:

1. Use existing local or regional land cover GIS layers (see Appendix B for potential sources)
2. Derive land cover from high-resolution imagery using GIS and remote sensing techniques
3. Use GIS to digitize land cover from recent aerial photos

If recent land cover maps of an appropriate scale and resolution are not available, one option is to acquire high-resolution satellite or aerial imagery and use remote sensing software to interpret and classify the images into the three land cover categories. Existing imagery that may be used includes USGS digital orthoquads and IKONOS satellite imagery. Minimum standards for measuring urban tree canopy include a resolution of 1 meter and imagery that is no more than 3 years old (CBP, 2004). Two techniques that utilize image classification to derive forest cover are the Baltimore Strategic Urban Forests Assessment and American Forests CITYgreen.

In the CITYgreen analysis, high resolution satellite and aerial imagery is used to create a tree canopy layer for input into the CITYgreen software. American Forests has developed a method of classifying the imagery to create this 'green data' layer. This layer is used to calculate the benefits of the canopy in terms of runoff reduction, air quality, carbon storage and energy savings. For more information about CITYgreen, see www.americanforests.org.

The Baltimore Strategic Urban Forests Assessment (SUFA) was modified from the Maryland DNR Strategic Forest Lands Assessment (SFLA) (MD DNR, 2003) for application to an urban area. The SUFA method involved acquiring high resolution satellite imagery of the study area and using remote sensing software and techniques to interpret the image by creating 'masks' of the tree canopy cover, non-tree vegetation and impervious surfaces within the jurisdiction. These masks were then overlaid with local land use, zoning and resource management data to create an 'opportunity mask' of potential planting sites prioritized based on local need. For a detailed description of the methods used, see Irani and Galvin (2002) or the SFLA website at http://www.dnr.state.md.us/forests/download/sfla_report.pdf.

A third option for deriving land cover is to acquire aerial photos and directly digitize land cover layers from these photos (see Appendix B for sources of aerial photos). This method can be time-consuming but may be more affordable than using satellite imagery, particularly if some of the land cover layers already exist in GIS format.

Once the GIS layer of current land cover has been acquired or developed, the area of each cover type in the watershed should be quantified (see Figure 9).

Step 1.2 Identify Protected and Unprotected Lands in the Watershed

The next step is to create or acquire a GIS layer of protected and unprotected lands, in both public and private ownership. Protected lands are defined as land protected from future development through the application of conservation easements or by local regulations that protect specific natural resources. The types of protected land vary in each watershed, but may include wetlands, floodplains, stream corridors or buffers, steep slopes, hydric or erodible soils, parkland, land in conservation easements, karst features, and historic or cultural sites. Protected lands can be digitized from paper maps or from aerial photos if they do not currently exist in GIS format. The final GIS layer should indicate which lands are protected. All remaining lands are designated as unprotected (see Figure 9).

Step 1.3 Determine Whether Parcels are Developed or Undeveloped

The next step is to create or acquire a GIS layer of developed and undeveloped parcels in the watershed to identify which parcels have already been developed, or 'built-out' to the maximum extent allowed by zoning (Figure 9). The development status (e.g., 'developed' or 'undeveloped') of a parcel may be readily available in the associated data table of a good parcel boundary GIS layer. Ideally, this layer will contain ownership data to be used later to prioritize sites based on ownership and to contact landowners about potential projects. If this is not the case, estimates of the development status of each parcel can be made by initially classifying all parcels containing buildings as developed. Aerial photos and local knowledge of the area can be used to verify this classification. Parcel boundaries can be digitized from paper maps if they do not currently exist in GIS format.

Alternatively, state planning agencies or the municipal department that handles land development permits may have a composite set of parcel maps in a digital format or a database of developed and undeveloped parcels (e.g., property tax maps) that can be linked to a GIS layer. One example is the Maryland PropertyView Database available from the State Planning Department: http://www.mdp.state.md.us/data/index.htm

Step 1.4 Determine Allowable Zoning on Undeveloped Land

Most local planning and zoning departments maintain a GIS and/or paper map of zoning categories. A zoning map dictates the allowable land uses and development densities within the community and provides a snapshot of what landuse will look like with future buildout. If a GIS layer of zoning does not exist, one can be digitized from the paper zoning map. If the watershed spans more than one community, zoning information from each community must be acquired and combined (see Figure 9).

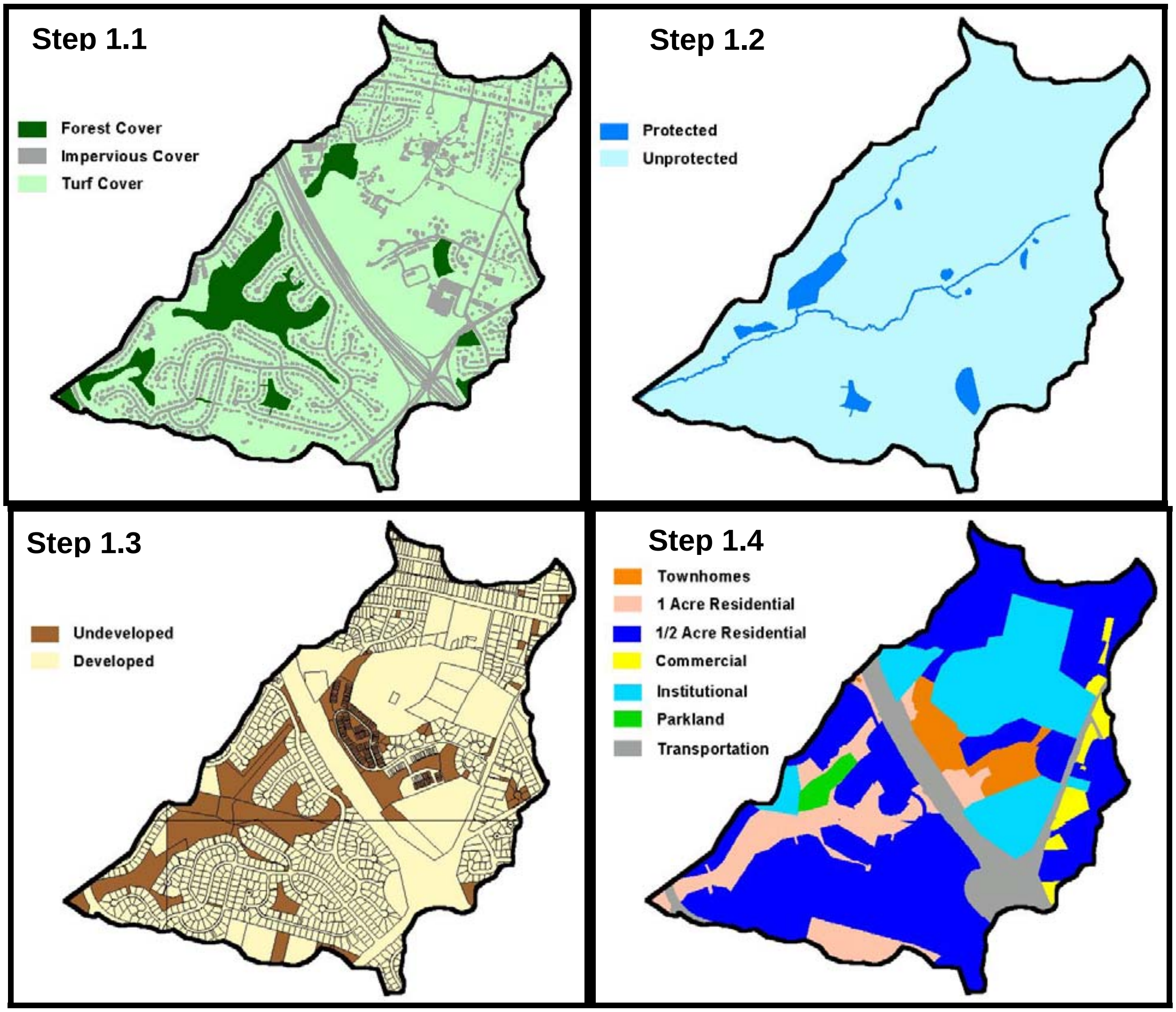


Figure 9. Example maps created as a result of the Leafout Analysis: Current Land Cover (upper left), Protected Lands (upper right), Development Status (lower left) and Zoning (lower right).

Step 1.5 Summarize Watershed Data

In this step, the data collected in the first four steps is used to develop a summary table that provides the necessary variables for estimating future forest cover (Table 4). This can be done using GIS by merging the four layers created in Steps 1.1 through 1.4 and querying the resulting data table. The variables highlighted in Table 4 will be plugged into a worksheet designed to estimate future forest cover in Step 1.7.

Table 4. Summary of Watershed Data

Zoning Category	Current Impervious Cover (acres)	Current Forest Cover (acres)		Current Turf Cover (acres)		
				Developed		Undeveloped
		Protected OR Developed	Buildable* (unprotected and undeveloped)	Public	Private	
Agriculture	100	1000	50	0	3000	50
Open urban land	150	2000	100	4000	0	0
2 acre residential	500	500	200	0	4000	1000
1 acre residential	1000	500	2000	0	2000	500
½ acre residential	1000	500	3000	0	1500	1000
¼ acre residential	2000	500	1000	0	1000	500
1/8 acre residential	2000	0	50	0	150	100
Townhomes	4000	0	500	0	100	400
Multifamily	3000	0	100	0	100	0
Institutional	1000	0	500	3000	500	0
Light industrial	5000	0	500	0	50	100
Commercial	5000	0	2000	0	500	500
Total	24,750	5000	10,000	7000	2950	4150

Each of the variables quantified in this step serves some function in estimating future forest cover:

- The *total amount of impervious cover* in the watershed will limit the potential for future forest cover (unless impervious cover is removed in order to reforest).

- *Forested land that is either protected or already developed* is assumed to remain forest with future watershed development.

- *Forested land that is both unprotected and undeveloped* is considered 'buildable,' and some proportion of that forest will be cleared during future development (Step 1.6 will estimate that proportion).

- *Developed turf* probably provides the best opportunities for reforestation, especially public lands because of ownership. However, only some proportion of public turf will actually be available for reforestation. Privately-owned developed turf is likely to be home lawns or commercial/industrial land and has the potential to greatly increase forest cover with reforestation, but will require extensive education, outreach and incentives to be effective.

- *Undeveloped turf* may also provide some opportunity for reforestation; however, this should always be done in conjunction with protection measures to ensure long-term sustainability of the forest.

Step 1.6 Acquire Forest Cover Coefficients

Forest cover coefficients represent the fraction of developed land that is forest. These coefficients are applied to specific zoning categories to estimate the amount of future forest cover on all buildable land in the watershed. Currently, little data exists for forest cover or turf cover coefficients. However, some data is available that represents the fraction of developed land that is impervious. The methods used to derive these impervious cover coefficients may be used to estimate forest cover and turf cover coefficients.

Impervious cover coefficients for 12 urban and suburban land uses are available from Cappiella and Brown (2001) and are presented in Table 5. These coefficients were derived from recently developed urban-suburban areas in the Chesapeake Bay region and are applicable to areas with similar types of development. Where possible, local or regional estimates of impervious cover should be used. If none are available, communities should derive their own from local data (see Cappiella and Brown, 2001 for methods). Communities should also derive their own forest and turf cover coefficients by analyzing limits of disturbance on site plans or by analyzing turf cover or forest cover at the parcel scale as a subsample of actual development sites. Appendix C and Cappiella and Brown (2001) provide detailed methods for deriving land cover coefficients.

Impervious, forest, and turf cover coefficients are provided in Table 5 for three forest conservation scenarios. The forest and turf cover coefficients are examples only and are loosely based on a number of assumptions and data sources described below. Additional data sources that may be used to develop land cover coefficients are provided in Appendix D.

Table 5. Example Land Cover Coefficients for Three Forest Conservation Scenarios

Zoning Category	Impervious Cover (%)[4]	Turf Cover (%)[5]			Forest Cover (%)[5]		
		NFC[1]	IFC[2]	DFC[3]	NFC[1]	IFC[2]	DFC[3]
Agriculture	0.02	0.93	0.83	0.78	0.05	0.15	0.20
Open urban land	0.09	0.86	0.76	0.41	0.05	0.15	0.50
2 acre residential	0.11	0.84	0.74	0.39	0.05	0.15	0.50
1 acre residential	0.14	0.81	0.71	0.36	0.05	0.15	0.50
½ acre residential	0.21	0.74	0.64	0.54	0.05	0.15	0.25
¼ acre residential	0.28	0.67	0.57	0.47	0.05	0.15	0.25
$^{1}/_{8}$ acre residential	0.33	0.62	0.52	0.47	0.05	0.15	0.20
Townhomes	0.41	0.54	0.44	0.39	0.05	0.15	0.20
Multifamily	0.44	0.51	0.41	0.36	0.05	0.15	0.20
Institutional	0.34	0.61	0.51	0.46	0.05	0.15	0.20
Light industrial	0.53	0.42	0.32	0.32	0.05	0.15	0.15
Commercial	0.72	0.23	0.13	0.13	0.05	0.15	0.15

[1]NFC = clearing can proceed anywhere at the site except protected wetlands.
[2]IFC = some site areas cannot be cleared because of steep slopes, wetland buffers, stream buffers, floodplains or other local clearing restrictions.
[3]DFC = additional site areas cannot be cleared because of explicit forest conservation or afforestation requirements at the site (e.g., Maryland Forest Conservation Law).
[4]Impervious cover coefficients from Cappiella and Brown (2001).
[5]Turf cover and forest cover coefficients are example values only.

The forest cover coefficients presented in Table 5 are representative of three tiers of local forest conservation regulations: No Forest Conservation (NFC), Indirect Forest Conservation (IFC) and Direct Forest Conservation (DFC).

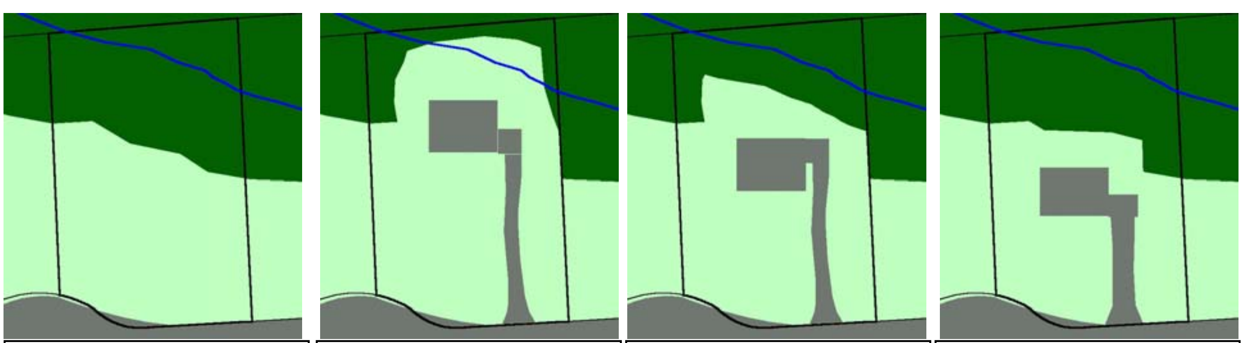
The *No Forest Conservation* scenario applies to communities that have no forest conservation or other natural resource conservation regulations that apply during land development. Under NFC, the entire site can be graded, except for state or federally delineated wetlands. For the forest cover coefficients presented in Table 5, the assumption was made that a minor fraction of forest cover (5%) may be retained during construction.

The *Indirect Forest Conservation* scenario applies to communities that have some additional regulations that prevent clearing on portions of a development site containing stream buffers, steep slopes, floodplains or other sensitive natural area. These areas often contain forest fragments, and therefore indirectly contribute to forest conservation, although they may represent a very small fraction of the site. The amount of forest conserved will vary depending on how much of the site is currently forested AND located within floodplains, steep slopes, stream buffers, etc. For the forest cover coefficients presented in Table 5, the assumption was made that approximately 15% of any given site would be preserved as forest.

The *Direct Forest Conservation* scenario applies to communities with defined forest conservation or afforestation requirements at the development site, in addition to the environmental criteria listed under the Indirect Forest Conservation scenario. The forest cover coefficients presented in Table 5 were primarily based on the Maryland Forest Conservation Act criteria, which require a certain percentage of a development site to be preserved as forest or reforested during development.

The turf cover coefficients presented in Table 5 reflect the remaining land after impervious cover and forest cover are subtracted from the total land area.

Figure 10 illustrates the three tiers of forest conservation regulations. Prior to development, the parcel shown in Figure 9 had 45% forest cover (dark green). With development under the NFC scenario, only a small portion of forest on the site was preserved, with a net forest cover of 10%. Under the IFC scenario, a stream buffer ordinance that restricts disturbance of native vegetation within 100 feet of all streams resulted in the developer conserving additional forest along the stream that runs through the property. The net forest cover for this scenario was 25%. Under the DFC scenario, a forest conservation ordinance that required preservation of 40% of the site as forest resulted in a net forest cover of 40% and total forest loss of only 5%.



Pre-Development 45% Forest Cover	No Forest Conservation 10% Forest Cover	Indirect Forest Conservation 25% Forest Cover	Direct Forest Conservation 40% Forest Cover

Figure 10. Effect of forest conservation regulations at the development site

Most communities fall into one of these three tiers of forest conservation and should select the appropriate forest cover coefficients depending on the prevailing regulations in their community. As illustrated in Table 5, land cover coefficients vary with the zoning category and the forest conservation scenario; however, one variable not reflected in this table is the prior landuse of the site. Land in agricultural use will have less forest cover to start with compared to a forested parcel so will likely have lower forest cover coefficients. In addition, forest cover coefficients that are derived for older developments may tend to be higher than for more recently developed areas because trees have been planted or allowed to grow up over time. This variability and the current lack of data on forest and turf cover coefficients points to the derivation of land cover coefficients as a major data gap in this analysis and area for future research.

Forest cover coefficients will be used in Step 1.7 to estimate future forest cover on buildable lands in the watershed. The default values shown in Table 5, or data provided in Appendix D may be used until detailed studies are conducted to derive additional data.

Step 1.7 Estimate Future Forest Cover in the Watershed

The final step in the Leafout Analysis is to estimate future forest cover in the watershed under full buildout conditions. This initial estimate of future forest cover is intended to quantify forest cover under a worst-case or 'do-nothing' approach and does not account for any future or planned forest conservation or reforestation efforts or regulations. Step 2, Develop Forest Cover Goals and Objectives, models the effect of various forest protection and reforestation techniques on future forest cover.

The text box below summarizes the assumptions used in estimating future forest cover. These assumptions should be modified when more detail is available regarding future development patterns in a particular watershed. The worksheet on the following page should be used to estimate future forest cover in the watershed under a worst-case scenario (e.g., no additional reforestation or conservation efforts). Data summarized in Table 4 (Step 1.5) and the forest cover coefficients acquired in Step 1.6 should be used to fill in the blanks in the worksheet.

ASSUMPTIONS USED IN ESTIMATING FUTURE FOREST COVER IN THE WATERSHED

1. All developed land will remain in its current land cover.
2. All protected land will remain in its current land cover.
3. All impervious cover will remain impervious (e.g., no removal of pavement).
4. All land that is unprotected AND undeveloped is considered “buildable” and is subject to future development under allowable zoning.
5. Full buildout of the watershed will occur based on allowable zoning (e.g., no re-zoning).
6. Future land cover of all buildable land can be estimated by applying the appropriate land cover coefficients for each zoning category.
7. The land cover coefficients chosen should reflect the current status of forest conservation regulations in the watershed.

Leafout Analysis Worksheet for Estimating Future Forest Cover in the Watershed Under Worst-Case Scenario (e.g., no additional reforestation or conservation efforts)

Area of Current Protected or Developed Forest:	*5000*	(acres)
From Table 4. All protected or developed forest will remain forest.	+	
Area of Forest Protected	*0*	(acres)
See table below. Default value is zero.	+	
Area of Forest Conserved During Development	*2780*	(acres)
See table below. Use forest cover coefficients that represent the current forest conservation requirements in your watershed.	+	
Area Reforested	*0*	(acres)
Default value is zero.	=	
Area Future Forest Cover	*7780*	(acres)

Zoning Category	Buildable Forest (acres)		Priority Forest Protected (acres)		Buildable Forest Remaining (acres)		Forest Cover Coefficient (%)		Forest Conserved During Development (acres)
Agriculture	*50*	-	*0*	=	*50*	*	*50*	=	*25*
Open urban land	*100*	-	*0*	=	*100*	*	*50*	=	*50*
2 acre residential	*200*	-	*0*	=	*200*	*	*50*	=	*100*
1 acre residential	*2000*	-	*0*	=	*2000*	*	*50*	=	*1000*
½ acre residential	*3000*	-	*0*	=	*3000*	*	*25*	=	*750*
¼ acre residential	*1000*	-	*0*	=	*1000*	*	*25*	=	*250*
1/8 acre residential	*50*	-	*0*	=	*50*	*	*20*	=	*10*
Townhomes	*500*	-	*0*	=	*500*	*	*20*	=	*100*
Multifamily	*100*	-	*0*	=	*100*	*	*20*	=	*20*
Institutional	*500*	-	*0*	=	*500*	*	*20*	=	*100*
Light industrial	*500*	-	*0*	=	*500*	*	*15*	=	*75*
Commercial	*2000*	-	*0*	=	*2000*	*	*15*	=	*300*
Total	*10,000*		*0*						*2780*

Summary Results

Current Forest Cover	*15,000*	(acres)		
From Table 4.	-			
Future Forest Cover	*7780*	(acres)		
From above.	=			
Future Forest Loss	*7220*	(acres)	*48*	(%)

The worksheet result gives an estimate of future forest loss (%) in the watershed with no additional forest conservation or reforestation efforts. In the example shown, 48% of existing forest in the watershed is lost to development.

The USDA Forest Service Northeastern Research Station is developing a new tool to project future forest canopy cover that may facilitate the Leafout Analysis. The tool involves a GIS-integrated management decision program that is a component of the Urban Forest Effects (UFORE) Model. This tool is called UFORE Future Effects and is designed to project future canopy cover over a 30-year period based on estimated growth and mortality rates. More information about UFORE is available at http://www.fs.fed.us/ne/syracuse/Tools/UFORE.htm and http://www.ufore.org/

Step 2: Develop Forest Cover Goals and Objectives

The second step is to develop overall goals for increasing forest cover in both the watershed and the community, and to identify specific objectives for attaining these goals. Forest cover goals should be specific, measurable and realistic, and have an associated timeline for attainment.

Step 2.1 Set Numerical Targets for Forest Cover

A numerical target for forest cover should be defined first for the entire community, and then for each individual watershed within the community. American Forests recommends 40% cover for most metropolitan areas, and a number of communities have already adopted this as a goal (see Appendix E). Across the U.S., tree canopy cover in urban and metropolitan areas currently falls below this standard, averaging 27% and 33%, respectively (Dwyer and Nowak, 2000).

A recent Chesapeake Bay Program directive encourages communities to adopt canopy goals (see text box below) and recommends that goals should: represent an increase in overall tree cover, be set for a 10-year horizon, and establish targets for percent increase in forest cover at specified intervals (CBP, 2004). Goals should also take into account current forest cover, current and planned development patterns and regulations, and resources available for reforestation and protection efforts. The Urban Forest Effects (UFORE) website provides data on current canopy cover for 21 U.S. cities that may be used as a starting point for developing community forest cover targets: www.fs.fed.us/ne/syracuse/Data/data/htmT.

Because most metropolitan areas contain multiple watersheds that often have varying land use and development patterns, a numerical target should be defined for each individual watershed, based on community-wide targets but taking into account specific watershed protection or restoration goals and using the results of the Leafout Analysis. It may not be realistic for some watersheds to meet the community-wide forest cover goal, while other watersheds may surpass them. To date, few communities have adopted numerical targets for forest cover at the watershed scale. However, some data indicates that watershed forest cover of at least 45 to 65% is most beneficial in terms of stream health (see Appendix E). These studies provide a starting point for setting watershed-wide forest cover goals. Table 6 provides some example forest cover goals for four watershed scenarios.

Table 6. Example Forest Cover Goals for Four Watershed Scenarios

Watershed Type	Impervious Cover %	Forest Cover Goal	Benefits of Forest Cover
Suburban/Forested	< 25	60% minimum with 70% riparian forest cover	• Maintain aquatic ecosystem • Improve filtering capacity • Wildlife habitat • Stream protection
Suburban/Agricultural	< 25	40-50% minimum	• Maintain aquatic ecosystem • Improve filtering capacity • Wildlife habitat • Stream protection
Urban-Suburban	26 to 60	25-40% minimum	• Storm water runoff reduction • Reduce urban heat island • Wildlife habitat • Increase aesthetic value • Provide recreational opportunities
Urban	> 60	15-25% minimum	• Reduce urban heat island • Storm water runoff reduction • Public health and air quality • Community livability

The forest cover goals presented in Table 6 are examples only and should be refined based on individual watershed characteristics, modeling or literature review to directly address storm water, air quality or other outcomes. Current forest cover should be used as a starting point for goal setting. Current watershed impervious cover may also help determine the maximum limit of forest cover that it is possible to achieve without removal of impervious surfaces. Numerical forest cover targets should be revisited periodically and revised if necessary. Cost estimates for implementing forest conservation and reforestation objectives are necessary for communities to determine what is a realistic forest cover increase to achieve given a specific timeframe and budget. Two examples are presented in the text box on the following page.

QUANTIFYING REALISTIC FOREST COVER GOALS

A study of the urban forest in Syracuse, NY found that the current forest cover in the city was 26.6% for the 25.1 square mile area. A specific recommendation was made in the city's Urban Forest Management Plan to increase overall canopy cover to 30%. Assuming that existing forest cover was maintained, this **increase of 3.4%** could be implemented over **25 years** by planting 1,360 new trees each year (Nowak and O'Connor, 2001). Annual costs for implementation are estimated at $272,000 (based on cost of $200 per tree for planting and maintenance from Connecticut Climate Change, 2004).

A similar study by the North East State Foresters Association (Luley and Bond, 2002) used a model to determine that a **10% increase in canopy cover** was realistic for the New York City metropolitan region (a 1950 square mile area) to achieve over a **30-year time period**. This increase would bring the total tree canopy cover up to 41%. To achieve this goal, more than 1 million trees would need to be planted each year at an annual cost of $212 million (using the above cost estimate).

Step 2.2 Define Priority Objectives to Meet Goals

Forest cover goals for a watershed should represent an increase in the existing percentage of forest cover. The specific objectives utilized to meet forest cover goals may vary with each watershed and should be based on the data derived from the Leafout Analysis (e.g., current impervious cover, area of protected forest, area of buildable forest, proportion of public and private developed turf). Table 7 provides guidance on identifying priority objectives to meet forest cover goals in specific types of watersheds.

Table 7. Linking the Leafout Analysis with Forest Cover Goals and Priority Objectives

Urban Watershed Forestry Objective	Characteristics of Watersheds Where Objective is Prioritized
A. Protect Priority Forests	Significant proportion of buildable forest, significant forest lost to development in leafout analysis scenario, large tracts of forest owned by single landowners
B. Prevent Forest Loss During Development/Redevelopment	Significant proportion of buildable forest, significant forest lost to development in leafout analysis scenario, current forest cover regulations do not directly or indirectly protect forests
C. Maintain Existing Forest Canopy	Highly developed watershed with little or no buildable forest remaining, majority of forest is on developed land
D. Enhance Forest Remnants	Significant protected forest exists, little remaining buildable forest
E. Plant Trees During Development/Redevelopment	Significant proportion of buildable land, current conservation regulations do not provide much protection of trees (and is not feasible or acceptable to change) or most of buildable land is turf (prior ag land)
F. Reforest Public Land	Significant proportion of public turf
G. Reforest Private Land	Significant proportion of private turf, private turf is held by a few large landowners, or private turf is held by many small landowners, but represents the best opportunity for increasing forest cover (e.g., very little forest exists to protect, little buildable forest left, little public turf)

Step 2.3 Evaluate Effect of Objectives on Future Forest Cover

The Leafout Analysis provides a baseline estimate of future land cover under a worst case or “do nothing” scenario. Based on priority forest cover objectives, alternative scenarios can be evaluated to determine their impact on future forest cover. The worksheet on the following page illustrates an example scenario in which future forest loss was reduced from a 48% loss to a 7% gain in watershed forest cover.

Leafout Analysis Worksheet for Estimating Future Forest Cover in the Watershed - Forest Conservation/Reforestation Scenario

Area of Current Protected or Developed Forest:	5000	(acres)
From Table 4. Protected or developed forest will remain forest.	+	
Area of Forest Protected	2000	(acres)
See table below. Select area to protect as part of an urban watershed forestry program.	+	
Area of Forest Conserved During Development	5000	(acres)
See table below. Use forest cover coefficients that represent the amount of forest conserved at a site with adoption of forest conservation or afforestation requirements.	+	
Area Reforested	4000	(acres)
Select area to reforest as part of an urban watershed forestry program.	=	
Area Future Forest Cover	16,000	(acres)

Zoning Category	Buildable Forest (acres)		Priority Forest Protected (acres)		Buildable Forest Remaining (acres)		Forest Cover Coefficient (%)		Forest Conserved During Development (acres)
Agriculture	50	-	500	=	50	*	50	=	25
Open urban land	100	-	500	=	100	*	50	=	50
2 acre residential	200	-	50	=	200	*	50	=	100
1 acre residential	2000	-	250	=	2000	*	50	=	1000
½ acre residential	3000	-	0	=	3000	*	50	=	1500
¼ acre residential	1000	-	0	=	1000	*	50	=	500
⅛ acre residential	50	-	0	=	50	*	50	=	25
Townhomes	500	-	0	=	500	*	50	=	250
Multifamily	100	-	0	=	100	*	50	=	50
Institutional	500	-	500	=	500	*	50	=	250
Light industrial	500	-	0	=	500	*	50	=	250
Commercial	2000	-	200	=	2000	*	50	=	1000
Total	10,000		2000						5000

Summary Results

Current Forest Cover	15,000	(acres)		
From Table 4.				
Future Forest Cover	16,000	(acres)		
From above.				
Future Forest Increase	1,000	(acres)	7	(%)

Figure 11 illustrates the effect of these objectives on future forest cover compared with future forest cover with no protection or reforestation efforts.

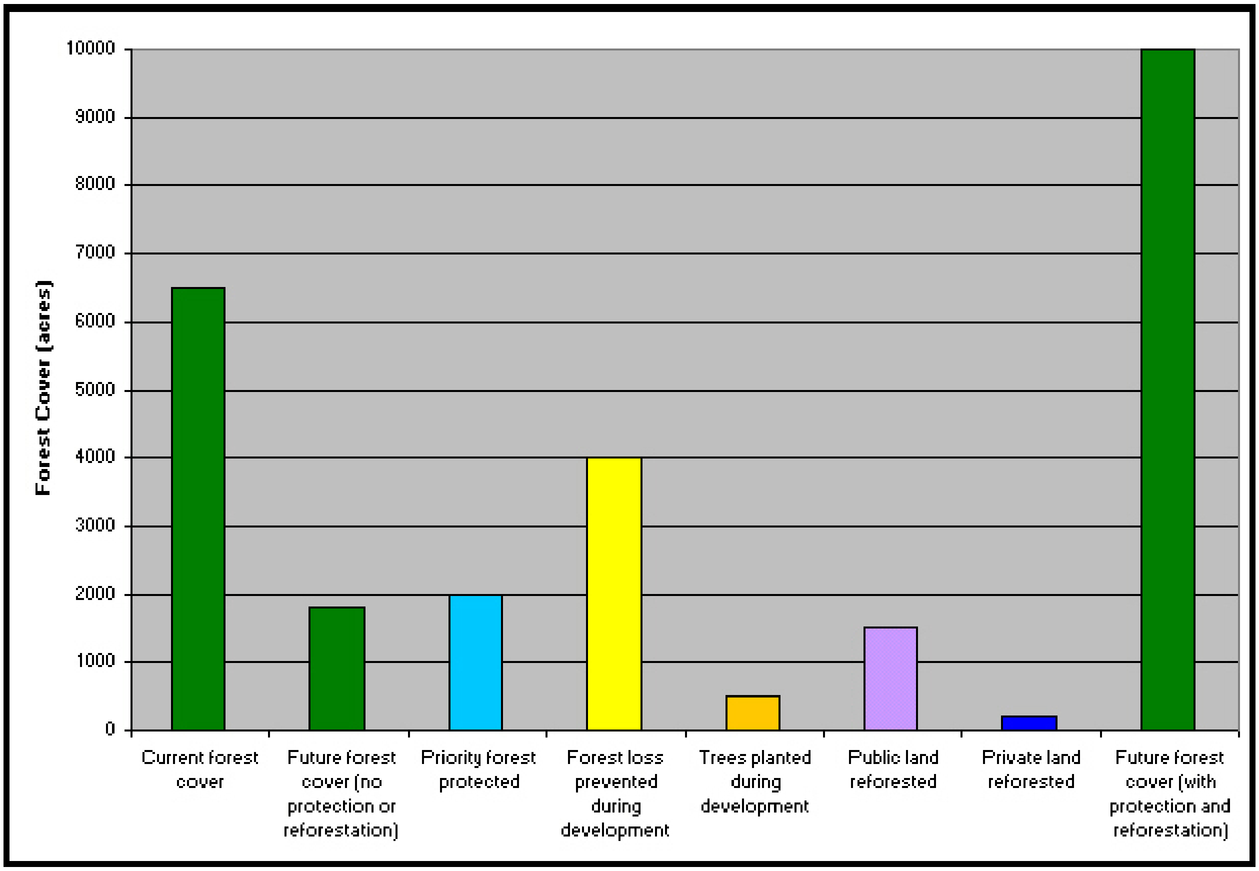


Figure 11. The effect of forest conservation and reforestation on future forest cover

Step 3: Identify Existing Forest and Reforestation Opportunities

Once numerical targets for protection of existing forest and reforestation are identified, the next step involves locating the best sites in the watershed for these activities. In this step, priority forest and reforestation sites are selected for further evaluation in the field based on the inventory of current land cover in the watershed. However, due to factors such as budget and land ownership, it is not desirable or feasible to pursue each and every forested site for protection, or each and every open area for reforestation. Using the information generated through the inventory of current and future land cover, as well as some additional land use and land owner information, a select number of sites can be identified through the use of a GIS. Table 8 identifies what are typically the best opportunities for each of the seven urban watershed forestry objectives.

Table 8. Types of Land Best Pursued for Urban Watershed Forestry Objectives	
Urban Watershed Forestry Objective	**Best Opportunities**
A. Protect Priority Forests	Large tracts of contiguous, unprotected forest
B. Prevent Forest Loss During Development/Redevelopment	Forest on parcels to be developed
C. Maintain Existing Forest Canopy	Forest on parcels that are already developed
D. Restore Forest Remnants	Protected forests
E. Plant Trees During Development/Redevelopment	Turf areas on parcels to be developed, including streetside planting areas, storm water treatment practices, property lines
F. Reforest Public Land	Turf areas on public-owned parcels that are already developed (e.g., parks, schools, stream buffers, STPs, rights-of-way) or undeveloped turf areas (provided reforestation is done in conjunction with protection measures)
G. Reforest Private Land	Turf areas on private-owned parcels that are already developed (e.g, home lawns, stream buffers, institutional and commercial land)

GIS layers created in Step 1 (current land cover, protection status, development status, zoning and future land cover) are combined with the following layers in this step:

- Property boundaries/land owner information
- Public lands (e.g., schools, parks, rights-of-way)
- Storm water treatment practices
- Vacant land
- Aerial photos
- Natural resource data (e.g., streams, wetlands, floodplains, critical habitats, karst features, steep slopes, erodible soils, monitoring data)
- Cultural, recreational or historical areas

Step 3.1 Identify Existing Forests for Further Assessment

To identify existing forests for further assessment, a watershed map that also identifies forested land that may be lost to future development (e.g., unprotected and undeveloped land) should be analyzed (Figure 12). It may also be useful to overlay other GIS layers on the map that define constraints on site selection, such as: land ownership, transportation corridor or utility restrictions, prior site use (e.g., potential for soil or groundwater contamination) and natural, cultural and historical resources.

Forests selected for further evaluation are assessed in the field to determine whether they are good candidates for protection or restoration and to select appropriate protection or restoration techniques. In highly urban watersheds where few remaining forests exist, it may not be necessary to whittle down the forested sites to a more manageable number. Criteria for selecting forested parcels for further evaluation include the following:

- Currently unprotected
- Publicly owned or willing land owner
- Contiguous forest greater than a specified acreage (set by municipality, dependent on average size of forest fragments)
- Strategic location in watershed (e.g, adjacent to existing forest parcel, reforestation site or protected land, connects or has the potential to connect two existing contiguous forest parcels, has significant natural, historic, cultural or recreational value)

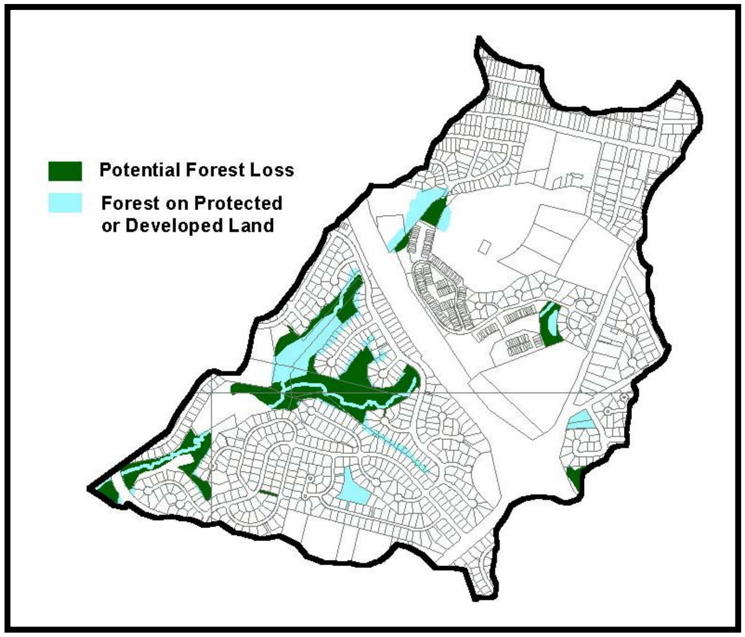


Figure 12. Potential Forest Loss

Each community should tailor these criteria for selecting forest parcels to take into account the specific characteristics of their watersheds. The possibility of expanding forested areas or linking them to the stream corridor or other remnants should always be considered when selecting priority forest sites. Owners of large forested tracts may be contacted at this stage to gauge their interest in forest conservation efforts, and to get permission to evaluate their land further.

Step 3.2 Identify Reforestation Opportunities for Further Assessment

To select reforestation sites for further assessment, a map that displays the existing non-forest vegetative cover in the watershed should be analyzed along with property boundaries, vacant lands, public lands, storm water treatment practices, and natural cultural and historical resource information.

Sites with turf cover typically present the best reforestation opportunities because they do not involve extensive removal of vegetation or impervious cover. If the GIS layer of land cover does not distinguish between turf and other types of non-forest vegetation, aerial photos may be used to verify which parcels contain turf. Turf cover typically represents the largest portion of non-forest vegetative cover and can comprise up to 80% of urban pervious cover (CWP, 2000b). Figure 13 shows the distribution of turf cover at the state level across various land uses (composite of MTC, 1996; VASS, 1998 and PTC, 1989).

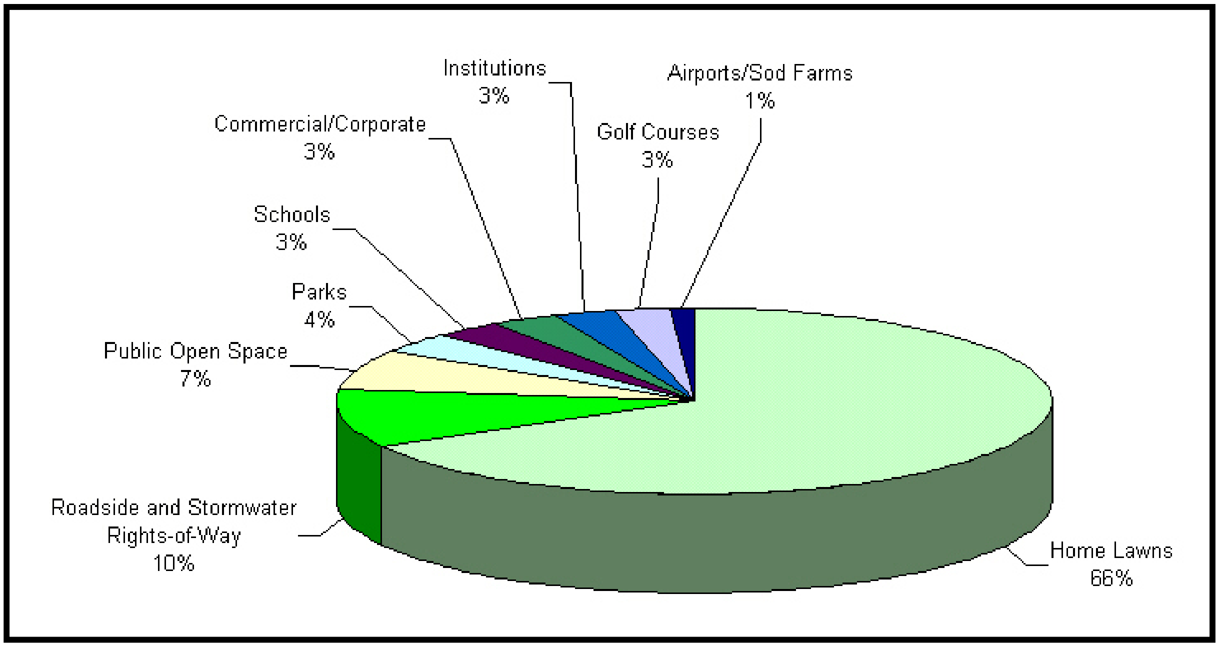


Figure 13. Distribution of turf cover at the state level (composite of MTC, 1996; VASS, 1998 and PTC, 1989)

As can be seen, home lawns constitute the largest single share of turf cover (about 67%). Public land such as rights-of-way, open space, parks and schools constitute about a quarter of the total turf cover. This distribution will vary from watershed to watershed, but home lawns and public land are typically the major components.

While reforesting home lawns may yield the largest increase in watershed forest cover, this can be difficult to accomplish because of the sheer number of landowners involved and potentially small number of homeowners who are willing to convert their turf to forest. If home lawns do comprise a significant portion of turf cover in the watershed, an education program geared towards homeowners about the benefits of planting trees, combined with a community tree planting or cost share program, may be the most effective tool for increasing forest cover on residential lots (GFC, 2001). The same approach may be used for private institutions, commercial land and multifamily housing complexes, which may also have large turf areas that can be reforested. Figure 14 illustrates that while private turf may present opportunities for extensive reforestation, the land is typically in the hands of multiple owners.

Public lands are attractive from the standpoint of reforestation because of their large size and ownership. These include highway cloverleafs and buffers, parks, schools, storm water dry ponds and utility corridors. Vacant lands and stream corridors provide additional opportunities to reforest the watershed. Criteria for selecting reforestation opportunities for further evaluation include the following:

- Turf cover
- Developed or vacant land

- Publicly owned (e.g., highway cloverleafs, highway buffers, parks, schools, storm water dry ponds, utility corridors)
- Strategic location in watershed (e.g, stream corridor, adjacent to existing forest parcel, reforestation site or protected land, connects or has the potential to connect two contiguous forest parcels, has significant natural, historic, cultural or recreational value)

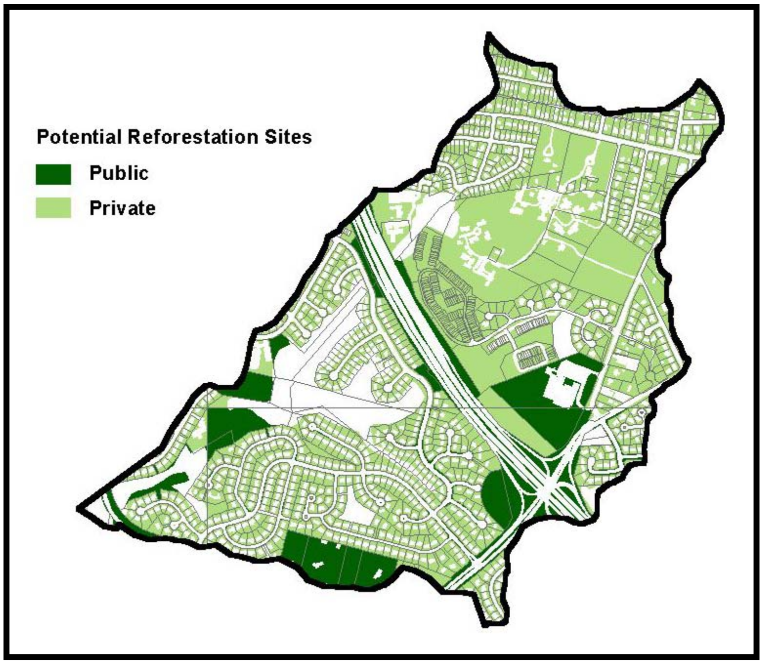


Figure 14. Reforestation potential

Each community should tailor these criteria to select reforestation opportunities that take into account the specific characteristics of their watersheds. For example, a community with a very large number of sites that meet the above criteria may elect to only evaluate turf parcels larger than two acres. The possibility of expanding existing forested areas or linking two forest fragments should always be considered when selecting priority reforestation sites.

Step 4: Conduct a Field Assessment of Existing Forest and Reforestation Opportunities

The next step is to select existing individual forest and/or potential reforestation sites for further evaluation in the field to verify their existence and use, determine if they are good candidates for protection, restoration or reforestation, and to collect some basic screening information to rank the sites.

Step 4.1 Conduct a Field Assessment of Existing Forest Fragments

Many methods exist for evaluating the quality of existing forests; however, few are specifically tailored to urban forests. Several forest assessment methods are summarized in Table 9, which address at least some of the potential impacts of development on forests. The priority forests selected in Step 3 should be assessed using one of these methods or an equivalent. The choice of which method to use and how many forested parcels to initially evaluate in the field will ultimately be driven by staff, budget, resources and the level of detail desired.

Table 9. Summary of Forest Assessment Methods			
Forest Assessment Method	**Applicability**	Description	**Source**
Unified Subwatershed and Site Reconnaissance (USSR)	Urban upland forests	The Pervious Area Assessment form of the USSR is used to collect basic information about existing forest remnants	Wright, *et al.* (2004)
Woodland Buffer Habitat Assessment	Riparian forest	Evaluates the value of riparian forest for wildlife habitat	Hanssen (2003)
Upland Contiguous Forest Assessment	Upland forests	Designed to evaluate large parcels of contiguous forest to determine which are priorities for conservation	CWP (unpublished)
Maryland's Green Infrastructure Assessment	Regional application	Evaluates hubs and corridors in terms of ecological significance for the purpose of land acquisition	Weber (2003)
Maryland Forest Conservation Act Stand Assessment	Parcel scale	Evaluates forest stands on an individual development site to identify conservation areas	Greenfeld, *et al.* (1991)

Each method collects similar types of information at forest fragments to evaluate the quality of the forest, identify potential restoration opportunities, and rank each site in terms of conservation priorities. These forest characteristics are presented in Table 10.

Table 10. Forest Characteristics Evaluated in Field Assessments	
Characteristic	**Description**
Basic site information	Landowner and use, parcel size, location, protection and development status
Surrounding landuses	Observe adjacent forest or open areas and evaluate potential for connection with these nearby fragments
Dominant species	Dominant tree species or forest association
Forest age	Indicated by successional stage or size class of dominant trees
Vertical structure	Presence of different vertical layers of vegetation such as ground cover, understory, mid-story and canopy trees. Measure of habitat complexity.
Canopy density & condition	Percentage of forest covered by tree canopy, Canopy condition and health.
Herbaceous vegetation	Density and species or herbaceous vegetation, presence of duff layer
Understory vegetation	Density and species of understory vegetation
Invasive species	Density, extent and species of invasive plant species
Indicator or rare, threatened, or endangered (RTE) species	Species and specific location. Indicator species are intolerant of a decline in habitat quality and are therefore indicators of high quality habitat
Evidence of disturbance	Clearing, trash dumping, erosion, pollution, overbrowsing
Presence of food, water, cover and habitat	Includes streams, wetlands, snags and cavity trees, large woody debris, conifers, mast species, vernal pools, leaf litter

Basic site information and surrounding land uses are evaluated to assess the feasibility of protecting or restoring the site and to use in ranking the site in terms of its potential to connect other forest fragments or habitat corridors. The remaining characteristics provide an overall indicator of the ecological significance or value of the forest. Most forest assessment methods will include a system for interpreting data collected in the field that results in an actual score or classification of the forest in terms of ecological value.

Step 4.2 Conduct a Field Assessment of Potential Reforestation Sites

Most potential reforestation sites are public or private turf. Turf areas should be assessed in the field to verify their condition, evaluate the feasibility of reforestation, and collect information to prioritize candidate sites. If desired, additional information may be collected at this time to use in developing a reforestation plan for the sites (e.g, detailed soil characteristics). Table 11 summarizes three assessment methods for evaluating urban reforestation sites. Additional information on evaluating plant sites is provided in Part 3: Urban Tree Planting Guide, and in Reynolds and Ossenbruggen (1991) and WFC (1993).

Table 11. Summary of Reforestation Site Assessment Methods

Reforestation Site Assessment Method	Applicability	*Description*	Source
Unified Subwatershed and Site Reconnaissance (USSR)	Urban upland pervious areas	The Pervious Area Assessment form of the USSR is used to collect basic information about potential planting sites	Wright *et al.* (2004)
Unified Stream Assessment	Urban riparian areas with inadequate stream buffer	The Inadequate Buffer form is used to collect basic information about potential planting sites with < 25 foot forested stream buffer	Kitchell and Schueler (2004)
Site Assessment for Urban Tree Planting	Urban planting sites	Detailed site assessment for urban tree planting to use in selecting species and developing a planting plan	Bassuk *et al.* (2003)

The types of information collected with each assessment method vary with the purpose of the assessment and location(s) in which they apply (upland or riparian). Table 12 provides a summary of the three types of information typically collected during a reforestation site assessment: feasibility factors, ranking factors and factors to use in creating a reforestation plan.

Table 12. Factors Evaluated in Field Assessment of Reforestation Sites

Factor Type	Description
Feasibility	Landowner and use, site access, potential soil contamination, lack of sun or water, severe and widespread invasive species or overbrowsing, conflicts with infrastructure
Ranking	Size and dimensions of planting area, location in watershed, surrounding landuse, potential for connection to nearby forest or protected land, presence of nearby streams, wetlands, RTE species or other sensitive resource
Reforestation Planning	Current vegetative cover, invasive species, trash dumping, soil pH, soil texture, soil compaction, soil drainage, soil salinity, soil depth, distance to water table, light exposure, heat exposure, wind exposure, slope, and potential for damage from vandalism, automobiles, deer, lawnmowers, etc.

The feasibility and ranking factors collected will be used in to prioritize sizes for reforestation (Step 5) and the reforestation planning factors collected will be used to determine exactly what to plant, where to plant and when to plan at the site (Step 6).

Step 5: Prioritize Existing Forest and Reforestation Opportunities

The next step is to prioritize the candidate sites identified in Step 4 for protection, enhancement and reforestation. The ranking system should take into account the forest cover goals for the watershed, as well as any larger watershed protection or restoration goals that have been defined. The ranking system should also be driven by the resources available for implementing watershed forestry projects, and will be based on results of both the inventory of watershed land cover and the field assessments. Therefore, some factors may be weighted more heavily that others. While the exact ranking system should be defined by the user, some important ranking factors to include are presented in Table 13.

Table 13. Common Ranking Factors to Prioritize Parcels for Protection, Enhancement or Reforestation

Ranking Factor	Description
Feasibility Ranking Factors	
Land ownership	Prioritize public land then private land with willing landowners
Access to site	Project may be infeasible if access to site is not adequate for any necessary foot traffic, vehicles or heavy equipment.
Prohibitive site characteristics	Certain site characteristics may make a project infeasible, such as potentially contaminated soils or insufficient sunlight for plant growth
Environmental Ranking Factors	
Continuity (if forest)	Prioritize sites with uninterrupted cover
Connectivity	Prioritize sites that link or have the potential to link adjacent forest, reforestation sites or protected lands
Contiguity	Prioritize sites with greater than a specified acreage
Ecological significance	Prioritize sites with high habitat scores, high fish and bug Index of Biotic Integrity (IBI) scores, mature vegetation, RTE species, or other sensitive natural resources, or streams identified as restoration priorities
Location in watershed	Prioritize sites located in riparian areas, wetlands, floodplains, steep slopes, erodible soils, recharge areas or other locations important to watershed hydrology and water quality.
Community Ranking Factors	
Recreational value	Prioritize sites with recreational value
Community acceptance	Prioritize sites that received community support and have a potential base of volunteers to help with tree planting or maintenance (this may entail a public meeting to get community input on projects)
Historic or cultural value	Prioritize sites with significant cultural or historical value
Difficulty Ranking Factors	
Cost	Prioritize sites with the lowest cost per acre
Level of effort	Prioritize sites that require minimal site preparation (soil amendments, removal of invasive species) over those requiring extensive site preparation

Separate prioritization methods may be developed to rank forested sites and reforestation sites. Several examples of detailed prioritization methods for protection, enhancement and reforestation projects are summarized in Table 14.

Table 14. Summary of Prioritization Methods for Protection, Enhancement and Reforestation

Prioritization Method	Applicability	Description	Source
Maryland's Green Infrastructure Assessment	Regional application	Prioritizes hubs and corridors for land acquisition based on ecological significance	Weber (2003)
Urban Riparian Restoration Project	Urban riparian areas	3-tiered ranking system for prioritizing riparian sites for reforestation	Virginia Department of Forestry (1993)
Watershed Analysis Extension for ArcView	Watershed scale	Provides tools for quantitatively ranking land in a watershed by estimated surface water quality impact	de la Cretaz, *et al*. (2003)
Chesapeake Bay Resource Lands Assessment	May be applicable at a variety of scales	GIS-based methods for identifying forests in the Chesapeake Bay watershed that are important for protecting water quality and watershed integrity	Painton-Orndorff, *et al*. (2004)
Forest Areas of Local Importance	County or regional application	GIS-based decision tool to identify critical forest areas for protection	NEGRDC (2004)
Urban Forest Effect (UFORE Model	Site level	GIS-based tool for selecting the best locations to plant trees to improve air quality and building energy conservation	USDA Forest Service (2004)

Step 6: Develop Recommendations for Meeting Forest Cover Goals

The last step is to integrate forest cover goals for the watershed in the context of a watershed plan. This plan should include specific recommendations for implementing protection, enhancement and reforestation techniques at priority sites.

Watershed planning is a unique forest protection tool in that it takes a landscape-level approach to conserving forests based on natural features rather than focusing on jurisdictional boundaries or an individual development site. A watershed plan should ideally be created for every watershed within a jurisdiction that seeks to maintain or increase forest cover and incorporates specific recommendations for how to do this. CWP (1998b) and Schueler (2004) provide detailed guidance on how to create watershed protection plans and subwatershed restoration plans.

A watershed plan should incorporate the forest cover goals developed in Step 2 as well as the priority objectives identified and any related numerical targets. The watershed plan should also include priority sites identified for protection, restoration and reforestation. Detailed information should be provided for the top priority sites, including the following:

- Specific techniques recommended for protection, enhancement or reforestation
- Cost estimates for implementation and maintenance
- Potential funders, partners and other entities who will be involved in project implementation and/or long-term maintenance (e.g., watershed organizations, homeowners associations or HOAs)
- Implementation schedule

This step will involve some decision-making as to what types of protection, enhancement or reforestation techniques to use at each priority site. Protection, enhancement and reforestation techniques are described in detail in Chapter 3.